Insolation and Temperature
Chapter 4

Energy, Heat and Temperature

- Difference between **Heat** and **Temperature**
  - **Temperature**
    - **Kinetic energy** -- internal energy of molecule movement
    - **Temperature** -- the average kinetic energy of the molecules in a substance
    - **Heat** – **energy that transfers from on object to another because of the difference in temperature**.

- **How to Measure Temperature**
- **Thermometers—measures temperature**
  - **Fahrenheit scale**
    - Used only in the US
    - Water Freezes at 32^{o} F
    - Water Boils at 212^{o} F
  - **Celsius scale**
    - Used throughout the rest of the world
    - Water freezes a 0^{o} C
    - Water boils at 100^{o} C
  - **Kelvin Scale**
    - Used in the scientific world

Solar Energy

- **Electromagnetic radiation**
  - **Energy from the Sun**
- **Electromagnetic spectrum**
  - **Different wavelengths of light**
    - Visible light – 0.4 -0.7
    - Violet, Blue, Green, Yellow, Orange, Red
  - **Ultra-Violet Radiation- Shorter waves than visible light – 0.1- 0.4**
    - Mostly absorbed by the Ozone Layer
  - **Infrared Radiation – Longer waves than visible light – 0.7 – 1.0**
    - From Near Infrared to Thermal infrared
- **Radiation from Earth**– **Terrestrial Radiation**
  - Long wave Radiation – about 4 micrometers
- **Solar Radiation is at a constant level**
- When it hits the Earth's atmosphere,
  - **Some reflected back**

- **The rest passes through the Atmosphere to be transformed into different energies.**

Basic Heating & Cooling Processes in the Atmosphere

- **Radiation or Emission**
  - The **process by which electromagnetic energy is emitted from an object**
    - The **hotter the object the more radiation it emits**
- **Absorption**
  - The **assimilation of electromagnetic waves by striking an object.**
    - **Different objects have different absorption abilities**
- **Reflection**
  - The **ability of an object to repel electromagnetic waves without altering either the object or the waves**
- **Scattering**
  - The **act of deflecting or redirecting light waves with gas molecules and particulate matter** in the air.
  - **Rayleigh Scattering – when the shortest wavelengths are scattered (violet and blue)– causes the "blue sky"**
  - Sunset or Sunrise– **all the blue waves scattered as the energy passes through a longer atmosphere (larger angle) red, orange, and yellow left**.
- **Transmission**
  - Process whereby **electromagnetic waves pass through a medium like class or clear water**
  - **The Greenhouse Effect– incoming short wave radiation enters an area, but the reflective longer waves cannot escape, causing the area to heat**.
- **Conduction**
  - **Movement of heat energy from one molecule to another without changes to their relative positions**
- **Convection**
  - **Heat is transferred from one point to another by the predominately vertical circulation of fluid, such as water or air.**
- **Advection**
  - **When the dominate direction of heat transfer is moving fluid horizontally**

- **Adiabatic Cooling and Warming**
  - **Whenever air ascends or descends, the temperature changes**
    - **Expansion: Adiabatic Cooling**
      - As air rises the air cools, as the molecules spread out loosing heat
    - **Compression: Adiabatic Warming**
      - As air descends it is compressed, the molecules collide and create heat

- **Latent Heat**
  - **Storage or release of energy**
    - **Evaporation**- liquid water changes to gases, energy is released, cooling happens
    - **Condensation**- gaseous water vapor turns to liquid energy is stored, heating happens

Heating of the Atmosphere

- **Global Energy Budget**
  - **100 units of Solar Radiation hit the atmosphere**.
    - Some absorbed
    - Some reflected
    - Some radiated
- **Total units radiated out 100 units**
- **Albedo**:
  - **The reflective value of an object**
    - The **higher the Albedo value the more radiation the object reflects**.
- The **atmosphere is heated by *Earth radiation*** rather than the **sun radiation**.

Variations in Heating by Latitude & Season

- **Angle of Incidence**
  - **Higher the angle (90%)**
    - The **smaller the area of Earth** receiving high energy (**warmer**)
  - **Lower the angle (10%)**
    - The **larger the area of Earth** receiving high energy (**cooler**)
- **Atmospheric Obstruction**
  - **The amount of atmosphere the energy passes through and the transparency of the atmosphere affects the energy received.**
- **Day Length**
  - **Duration of sunlight affects the energy received**.
- **Latitudinal Radiational Balance**
  - **Low Latitudes – more solar energy**
  - **High Latitudes – less solar energy**
  - **Balanced across the atmosphere**

Land & Water Contrasts

- **Heating**
  - **Specific Heat**
    - Amount of energy required to raise 1 gram of substance by 1 degree Celsius
  - **Transmission**

        - Water is a better transmitter of sunrays than land
    - **Mobility**
        - Water is highly mobile and moves heat broadly and deeply
    - **Evaporative cooling**
        - **Evaporative cooling is more prevalent over the water than over land. Latent heat is needed for this evaporation keeping the surface of water cooler.**
- **Cooling**
    - **Land cools more rapidly than water**
- **Implications:**
    - **<u>Hottest and coldest areas of the earth of inland</u>**

Mechanisms of Heat Transfer

- **Atmospheric Circulation**
    - **Ocean Currents**
        - Close relation of the atmospheric circulation with ocean currents
        - Heat transfer by this circulation
- **Basic Patterns**
    - North Pacific, South Pacific, North Atlantic, South Atlantic, and South Indian
        - Continuous flow- West Wind Drift
- **Current Temperatures**
    - <u>Low Latitude currents – warm</u>
    - <u>Poleward – moving currents on western sides – warm</u>
    - <u>Northern Components – warm north and east</u>
    - <u>Southern Components – combined with the West Wind – usually cool</u>
    - <u>Equator-ward moving currents on the eastern side – cool</u>

Vertical Temperature Patterns

- **<u>Environmental Lapse Rate</u>**
    - Observed trend of vertical temperature change in the atmosphere.
- **<u>Average Lapse Rate</u>**- normal vertical temperature gradient of the troposphere.
    - **The average rate of temperature change is about <u>3.6 degrees per 1000 feet</u>.**
- **<u>Temperature Inversions</u>**
    - **Temperature increases with altitude**
        - **<u>Surface inversions</u>**
            - **<u>Radiation inversion</u>** – rapid radiation cooling – long cold winter nights
            - **<u>Advection inversion</u>** – horizontal inflow of cold air– maritime air blowing in from the sea
            - **<u>Cold-Air-Drainage inversion</u>** – cold air sliding down a slope into a valley

- **Upper Air Inversion**
  - **Result of air sinking from above –subsistence inversion**

Global Temperature Patterns

- Patterns of temperature controlled by **four factors**– shown on maps with **Isotherms**
  - **Altitude**
  - **Latitude**
  - **Land-Water Contrasts**
  - **Ocean Currents**

- **Altitude**
  - **Complexity of the land, makes temperature depiction tricky**
  - Use of the **average lapse rate** reduces the temperature to what it would be at sea level.
- **Latitude**
  - **East-west trend of temperatures roughly along parallels**.
- **Land-Water Contrasts**
  - Differences apparent on a map.
  - Summer and winter extremes apparent over continents more than over the water.
  - In **southern latitudes, the isotherms are more regular because of the presence of more water**.
- **Ocean Currents**
  - Obvious bends in the isotherms are along the coastal waters
  - These follow the ocean currents, - warmer seasons over the warmer currents, and cooler seasons over the cooler currents.
- **Seasonal Patterns**
  - Latitudinal shift of the isotherms
  - **Changes in the seasons**
    - Over **tropical areas little changes**
    - Over the **mid latitudes, basic seasons**
    - Over the **higher latitudes, seasons are cool, even in summer months**
- **Average Temperature Range**
  - The **average temperature between the warmest and coldest months**

Global Warming and Greenhouse Effect

- What do you think about this highly controversial happening?